Technical Overview for Science Case Subcommittees

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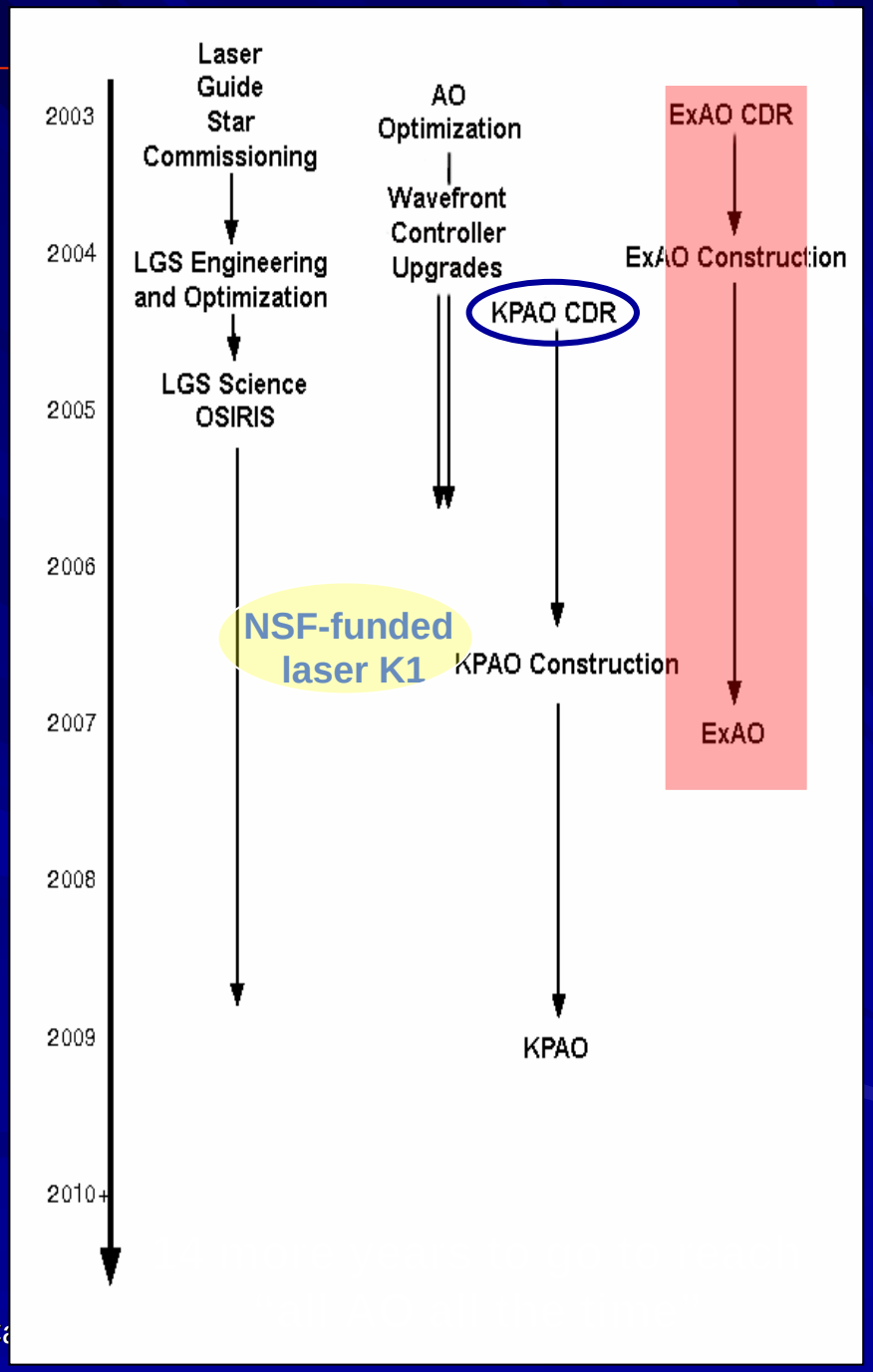
Presentation Sequence

- AOWG Strategic Plan
- KPAO Requirements & Performance
- Science Instruments
- Future AO Capabilities (building on KPAO)
- The Competitive Landscape

AOWG Strategic Planning

- Proposed timeline defined at 11/02 Strategic Planning (SP) meeting.
  - K1 laser added in early 03
- Priorities confirmed at 9/04 SP meeting.
- Mike Brown: "AOWG vision is that high Strehl, single-object, AO will be the most important competitive point for Keck AO in the next decade."
  - Based on science cases presented/discussed by AOWG members
  - Top-level requirements defined by a subgroup & approved by AOWG



KPAO - Requirements

KPAO High-level Performance Requirements Summary:
(based on AOWG 11/12/02 strategic plan report & KAON 237)

Parameter	Requirement	Notes
High IR Strehl ratios	rms wavefront error = 120 or 180 nm (cases to be evaluated)	On-axis (LGS & NGS) case under median seeing conditions, < 45° zenith angle, NGS V < 17 mag. Includes atmospheric, telescope, AO & science instrument contributions.
High Strehl stability	rms wavefront error maintained to ± 15 nm	
Moderate field of view	Science: 60” WF sensor: 60” TT sensor: 120”	Diameter. For sensing this is field of regard.
Sky coverage	Near complete	
PSF	Good knowledge	Requires well calibrated real-time diagnostics
Wavelength coverage	Science: 0.45 to 14 μm	
Class	Facility-class	

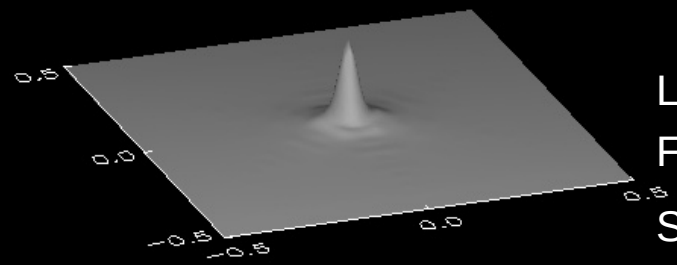
See KAON 237 for additional constraints: http://www2.keck.hawaii.edu/optics/kpao/files/KAON/kaon237.doc

Keck AO and KPAO compared

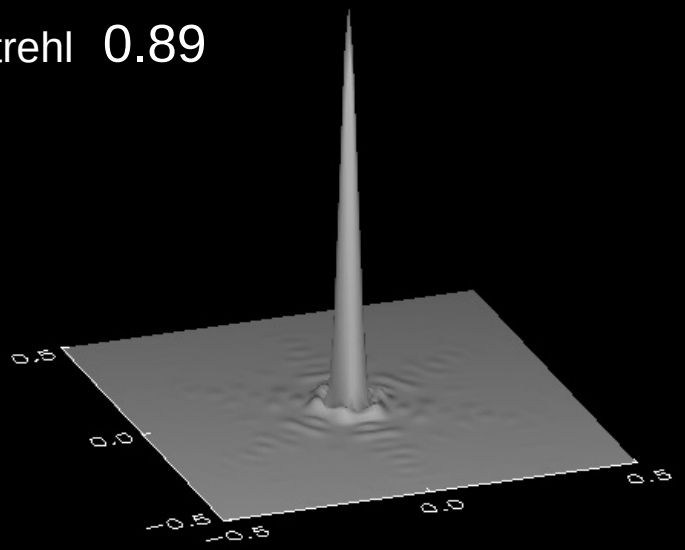
Simulation of AO systems
V=14 natural guide star,
2.1 microns (K band)

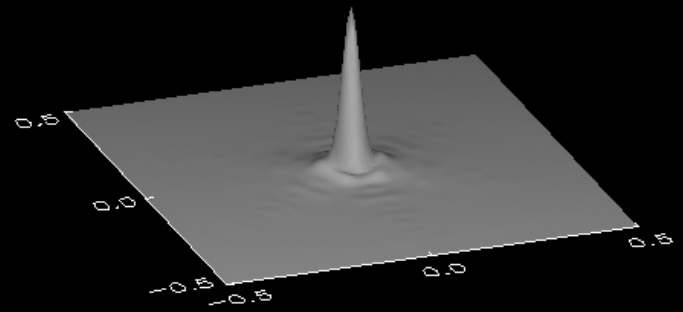
KPAO
FWHM 46 mas
Strehl 0.89

Natural Guide Star
FWHM 53 mas
Strehl 0.19

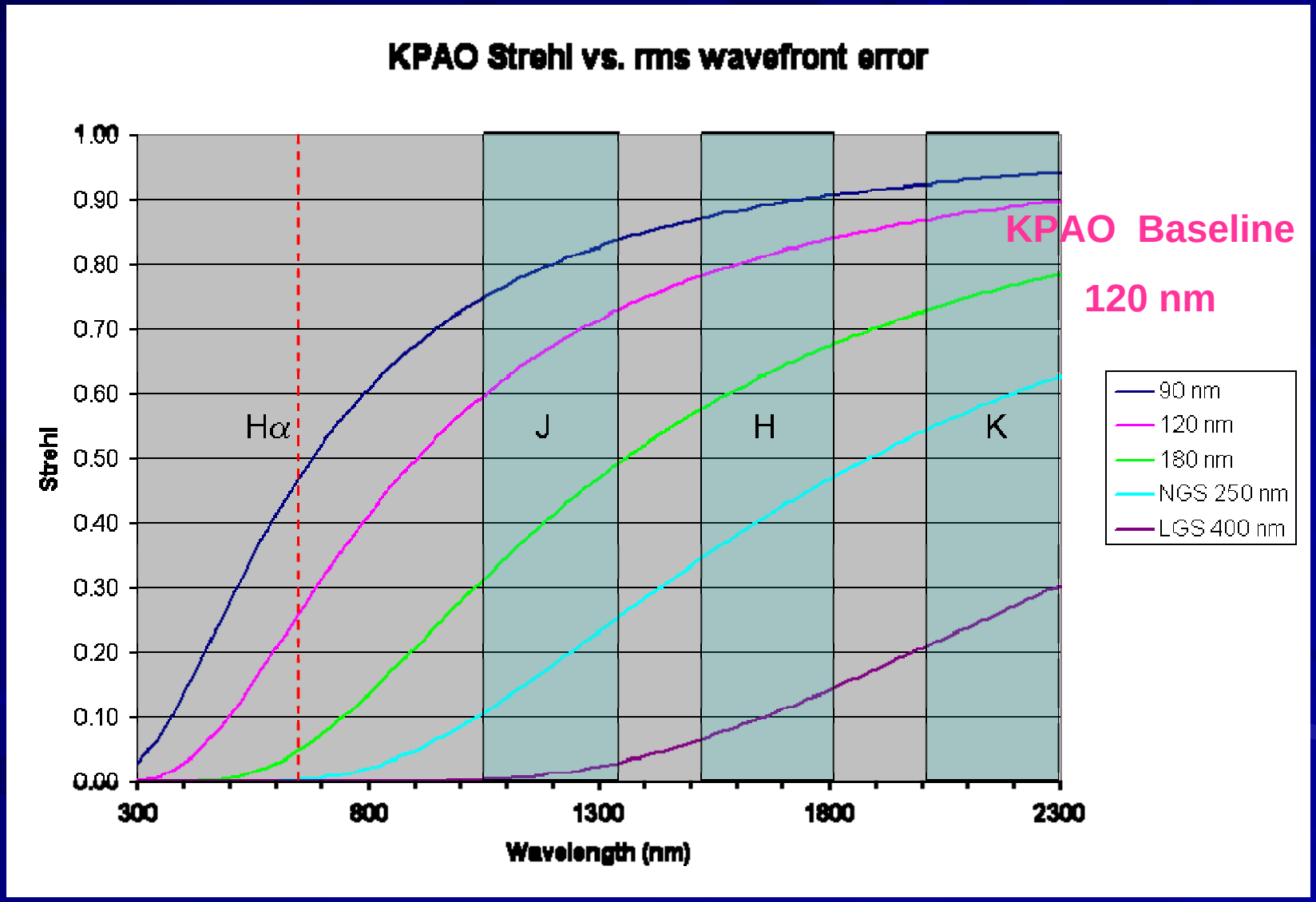


Laser Guide Star
FWHM 47 mas
Strehl 0.36

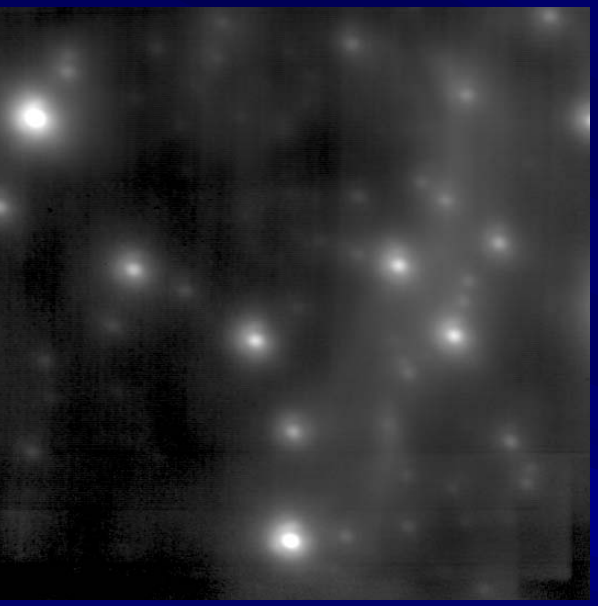


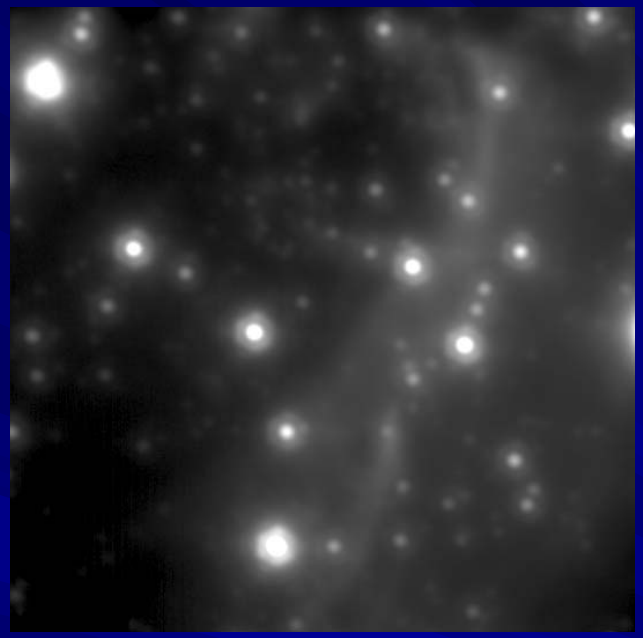


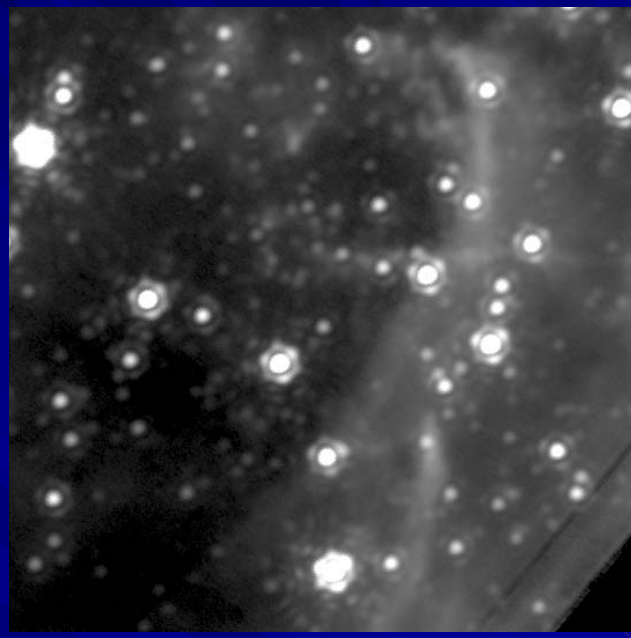
Keck NGAO


KPAO Strehl vs. rms wavefront error
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Strehl
300
800
1300
1800
2300
Wavelength (nm)
Hα
J
H
K
KPAO Baseline
120 nm
90 nm
120 nm
180 nm
NGS 250 nm
LGS 400 nm

KPAO: Predicted Performance







Hα Strehl ~0.2
Resolution 4x HST
& collection gain
16x HST

J-band Strehl ~0.6
Comparable to
current AO at K
with ~2x resolution

K-band Strehl ~0.85
Highest contrast
Best separation in
crowded fields

KPAO: Key Predicted Parameters

- ~ 1300 actuators (40x40 subapertures)
- 1500 Hz bandwidth
- 7x 20W lasers
- 1 e- wavefront sensor read noise
- Partial correction of NGS needed to achieve reasonable sky coverage (IR tip/tilt sensor; partial MCAO?)

Science Instruments

- Not yet defined
- Some ideas
  - Start with OSIRIS
  - Rebuild NIRC2 to higher wavefront quality
  - Larger field IR Integral Field Spectrograph
  - Visible imager
  - Visible Integral Field Spectrograph
- Interferometer: Must still AO correct both telescopes

Keck NGAO

Potential Synergy between KPAO & Future AO Capabilities

KPAO
High IR Strehl
Narrow FOV
Visible Capability

KPAO measures turbulence using multiple LGS & tomography

Wide-field AO can use these measurements to correct atmosphere

KPAO
High visible Strehl
Narrow FOV

Multi-Conjugate AO
Moderate IR Strehl
~ 2' FOV
Multiple DMs

Multi-Object AO
High IR Strehl
~ 7' FOR
AO postage stamps (MEMs) within FOR

Keck NGAO The Competitive Landscape

Instrument	Telescope	Capabilities	Dates	Phase
WFPC2	HST		-2010	Operation
Keck II LGS with NIRC2 & OSIRIS	Keck II	SR =30-40% at K, SR=10% @ K (R=19)	2004-	Operation
Altair with LGS	Gemini-N		2006-	Telescope I&T
NACO with LGS	VLT		2006-	Telescope I&T
LGS AO	Palomar		2006-	Telescope I&T
Laser (Rayleigh) Tomography AO	MMT		2006-	Telescope I&T
Coronagraphic Imager (CIAO) LGS AO	Subaru	188-act curvature, 4W SF laser SR=0.56 at K (V=10) 1kx1k InSb (11,22 mas/pix)	2007-	Development
MCAO	Gemini-S	2' science field	2007-	Development
Keck I LGS with OSIRIS	Keck I	20W laser, center projection	2008-	SDR
Adaptive Secondary + Pyramid WFS	LBT		2008-	Development
GTCAO LGS upgrade	GTC		2008-	Concept
LGS Multi Unit Spectrograph Explorer	VLT	SR~10% in visible, 5-10" fov	2008-	Final design
PALM-3000 + Oxford SWIFT	Palomar	149 nm wfe LGS, 98 nm wfe NGS, red optimized 44x89 IFU	2009-	Proposal
Planet Imager (GPI)	Gemini-S		2010-	Prelim Design
Adaptive Secondary	VLT			Prelim Design
Four LGS Facility (LGSF4)	VLT			Approval?
Planet Finder	VLT			Study
Multi-seeing reducer (FALCON)	VLT	Deployable mini-IFUs with MEMS, near IR, 20-30' FoR		Study
Next Generation Keck AO	Keck II		2012-	Study
Visible All Sky AO (VASAO)	CFHT	>0.6μm diff-limit <0.6mm 50mas	2012-	CoDR
NIRCam	JWST	< 0.1" images, 0.6-5 μm, 2.3x2.3' field	2014-	Design
NIRSpec	JWST	100 objects, 1-5 μm, 3x3' field	2014-	Design
IRIS (IR Imaging Spectrometer) with NFIRAOS (Narrow Field IR AO System)	TMT	1-2.5 μm, R~4000 1st light: 199nm rms (r0=15cm) Upgrade: 169nm rms	2015-	Feasibility
IRMOS	TMT	0.8-2.5 μm, R~2000-10000 50% EE in 50mas, N=16 multiplex, FoR = 5', full sky coverage	2016-	Feasibility
PFI (Planet Formation Instrument)	TMT	1-2.5 μm, 10^8 contrast	2015-	Feasibility
NIRES (Echelle Spectrometer) & WIRC (Wide-field Infrared Camera) with NFIRAOS	TMT		2019-	Concept